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THE NUCLEAR HARDENING OF ARMY TACTICAL SYSTEMS: A TRADE-OFF METHODOLOGY

R. Michael Schwenk
J. Terrence Klopcic

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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Presented is a trade-off methodology for quantitatively optimizing the nuclear hardening of Army tactical systems based on operational impact and life-cycle cost. Included is a proposed set of procedures and analyses which provide a systematic approach for ensuring nuclear hardening predicated upon mission-related survivability criteria and relative military worth. The methodology closely parallels current COEA designs and, as such, is applicable as a comprehensive, readily-adaptable, Army-wide program.

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I. INTRODUCTION

A. Purpose

A comprehensive, definitive methodology upon which to base nuclear hardening decisions regarding Army tactical systems is required. Currently, the decision to nuclear harden is founded on the piecemeal selection of systems which are readily adaptable to established nuclear survivability criteria - the levels, rationale, and impact of which are educated estimates at best. A program of this nature not only limits the scope of Army systems deemed eligible for consideration but, more importantly, fails to incorporate a relative or comparative matter of choice upon which a sound "go/no-go" judgement can be made. To overcome this problem, the quantitative assessment of a set of hardening alternatives is required to establish not only the operational impact of each, but the associated life-cycle cost. By using such an assessment technique, the ultimate decision as to the hardening of Army tactical systems rests on an analytical preview of relative worth.

A proposed set of procedures and analyses to determine these quantitative measures of operational impact and cost are outlined in this report. A general, systematic approach for ensuring nuclear hardening predicated upon mission-related criteria and relative military worth, applicable as an Army-wide, life-cycle program, is presented.

B. Scope

This report presents a trade-off methodology for quantitatively optimizing the nuclear hardening of Army tactical systems (NHATS). It is a comprehensive effort designed to address all Army materiel on a life-cycle basis. A brief background describing the motivation behind the NHATS development is presented and the concept of the methodology is described including a list of underlying principles and critical constraints. This is followed by the design of the methodology and the interfacing of NHATS with current Army programs. Implementation follows with agency liaison and a "walk-through" discussion. Finally, NHATS is summarized and recommendations for follow-on efforts are detailed.

It should be stressed from the onset that the methodology presented in this report is a management tool. It is a <u>means</u> toward an end. As such, the flavor of the discussion is of a "how-to" nature, with the scope intentionally left short of actual demonstration.

C. Background

Recently[1], it has become incumbent upon the combat and materiel developers of today's Army systems to address, more closely, the issue of nuclear survivability. In particular, efforts are under way to ensure that (1) all Army materiel is considered for nuclear hardening, (2) mission-related criteria are applied to equipment selected for hardening, and (3) hardening is addressed early in the materiel acquisition cycle. In addition, a new procedure has been established to control the granting of waivers pertaining to nuclear survivability requirements with the intent being to ensure consideration of all trade-offs during the decision-making process.

To aid in the application of the above programs and, more generally, to address the ultimate goal of an Army-wide, life-cycle nuclear hardening assessment, a comprehensive trade-off methodology for analyzing and optimizing the relative worth of hardening alternatives has been developed. The concept, design, and implementation of this methodology follows.

II. METHODOLOGY

A. Concept

The NHATS concept is much like any project management control system. It is a set of principles, practices, and procedures designed to identify and address both the immediate needs and the ultimate goals of a proponent organization. NHATS is responsive to the immediate needs of its user in that it is very much a task-oriented methodology, e.g., it identifies what is required and who is to supply it. The ultimate goals are addressed in terms of a quantitative operational impact and cost effectiveness assessment of the system being considered for nuclear hardening. NHATS falls short of arriving at a decision for one hardening alternative over another in recognition of the fact that such final decisions are not within the purview of a trade-off methodology. What NHATS will do, however, is to rank order the alternatives and recommend a preferred candidate to the ultimate decision maker. In short, then, the concept of NHATS has been divided into immediate needs ("nuts and bolts") and ultimate goals (end-product). Together, these two will drive the design of the methodology. First, however, a foundation of principles and constraints must be identified upon which the NHATS framework will be built. We begin first with the immediate needs.

Three major factors were selected as essential for the conceptual development of the methodology itself:

1. Relative Importance - The conduct and outcome of NHATS is tied directly to the relative importance placed on the project by the different agencies/personnel involved.

2. Complexity - A necessary parameter in terms of time, funding, human resources, and technical resources.

3. Uncertainty - Inherent in any trade-off analysis involving analytical techniques and quantified output is the question of whether the results are meaningful.

The first of these, relative importance, ties in directly with NHATS as a project management control system. This concept calls for four sub-factors:

(1a.) Obtaining Commitment

(1b.) Gaining Visibility

(1c.) Achieving Transition

(1d.) Effecting Integration

As the design of NHATS evolves later in this report, these four sub-factors will be prime issues. The successful conduct of NHATS is heavily dependent upon them, and the design must reflect this.

The second major factor is complexity. Again four sub-factors have been pinpointed under this category and are presented here in terms of constraints, or more appropriately, a set of standards.

(2a.) Responsiveness - The methodology must be responsive, supplying results in a matter of months, if not weeks.

(2b.) Flexibility - The methodology must be sufficiently flexible to handle any system, e.g., from main battle tanks to theater-wide communications.

(2c.) Limited Resources - The methodology must be "in-house" capable, relying on currently available Army agencies, personnel, and technical resources.

(2d.) Independence and Validity - The methodology must provide for independent (i.e., not developer-generated) operational impact and cost estimates which can be validated by appropriate commands.

As with the relative importance factors, the preceding also play a crucial role in the design of the methodology. Failure to comply with these standards is failure to develop an adequate model. Thus, these sub-factors will dominate NHATS' development.

The last major factor listed for NHATS is uncertainty. Within this heading the methodology should determine the uncertainty associated with:

(3a.) Scenario and Threat

(3b.) Combat Simulations

(3c.) Costing Estimates

(5d.) Vulnerability/Effects Data

These uncertainty analyses must be an integral part of each step of the methodology. They are to be considered an inherent process throughout NHATS, and the end product must reflect this to lend meaning or credibility.

Table I is a summary of the factors considered in the conceptual development of the trade-off methodology. These reflect those principles which will be applied to the design of the functional framework of NHATS. In essence, these factors are the basis for the "nuts and bolts".

Table I. NHATS Concept - Immediate Proponent Needs

NHATS AS A PROJECT MANAGEMENT CONTROL SYSTEM - IDENTIFY AND ADDRESS . . .

- RELATIVE IMPORTANCE
  - VISIBILITY
  - COMMITMENT
  - TRANSITION
  - INTEGRATION
- COMPLEXITY
  - RESPONSIVENESS
  - FLEXIBILITY
  - LIMITED RESOURCES
  - INDEPENDENCE AND VALIDITY
- UNCERTAINTY
  - SCENARIO AND THREAT
  - COSTING ESTIMATES
  - COMBAT SIMULATIONS
  - VULNERABILITY/WEAPONS EFFECTS DATA

Turning now to the ultimate goals of the NHATS methodology, recall the requisite end-product: optimizing the relative worth of hardening alternatives based on quantitative operational impact and life-cycle cost assessments. To attain such results one must accept three underlying premises:

1. A system's end use and design are not independent.

2. Survivability is a function of cost and operational effectiveness.

3. The tactical nuclear battlefield is in reality a nuclear/conventional mix.

Though strikingly fundamental in nature, these three facts have never been incorporated into a viable program for nuclear hardening. In terms of end use, detailed analyses of the operational context within which a system will be expected to operate have not been used as a means of determining mission-related survivability criteria. As for system design, nuclear survivability criteria have typically been the first to be waived as project managers approach cost limits, or design constraints, without regard to end use on the battlefield and force survivability. On the other extreme, hardening requirements have been met on some high-dollar items such as tactical nuclear weapon delivery systems. The probable employment of these systems and deployment of nuclear weapons against them is such that a system will either experience environments many times higher than the chosen hardening levels, or will experience no threat at all. In such cases end use analysis would indicate as fallacious any attempts at hardening. In other words, the end use analysis is as much a part of the design process as desired performance characteristics. Understanding operational context puts into perspective such factors as red targeting doctrine, target acquisition, and layout on the battlefield. It is fundamental to the development of mission-related nuclear survivability criteria and in determining the relative worth of hardening alternatives.

That survivability is a function of operational effectiveness is not so profound, but that it is also a function of cost may be. Yet the most important constraint on any major item of equipment is most often its ultimate cost. This cost cannot simply reflect the dollar value to produce a single issue of the item, but must incorporate all costs over the life-cycle (Currently, 20 years is used as a normal life-cycle). The true value of materiel has not been determined until such life-cycle costs have been evaluated.

Finally, a need exists to combine the conventional battlefield and conventional hardening techniques with the nuclear battlefield and nuclear hardening techniques. Unequivocally, the conventional and tactical nuclear battlefields are one and the same. Yet the development of Army materiel to date has not incorporated this fact. It is virtually certain that tactical nuclear exchanges will be preceded by and followed by conventional battle. Thus, the techniques for hardening must be considered in such a setting. The hardening alternatives selected must be tested in both environments. Indeed, it has been shown[2] that conventional hardening techniques can aid in nuclear survivability and viceversa. Therefore, until the end use is understood and until the costs are ascertained, any hardening alternatives selected may be ineffectual in terms of the true military worth of a system. Table II summarizes the ultimate goal concepts of NHATS as outlined above. With these precepts in mind, the NHATS design may proceed. The "nuts and bolts" and what they are to achieve now have a set of principles upon which they can be built.

Table II. NHATS Concept - Ultimate Proponent Goals

ULTIMATE PROPONENT GOALS . . .

- TO ANALYZE AND OPTIMIZE THE RELATIVE WORTH OF HARDENING ALTERNATIVES BASED ON QUANTITATIVE OPERATIONAL IMPACT AND LIFE-CYCLE COST ASSESSMENTS.

BASED ON THREE KEY PREMISES . . .

- A SYSTEM'S END USE AND DESIGN ARE NOT INDEPENDENT.
- SURVIVABILITY IS A FUNCTION OF COST AND OPERATIONAL EFFECTIVENESS.
- THE TACTICAL NUCLEAR BATTLEFIELD IS IN REALITY A NUCLEAR/ CONVENTIONAL MIX.

B. Design

Achieving the most cost effective and timely start-up of any new program necessitates a first look at the possible reliance on those programs which have preceded it. This reliance must be of such a nature that it does not create new responsibilities or job designs, but merely fits into the functions of organizations as they currently exist. Referring back to Table I, the most efficient manner for a new program to realize visibility, commitment, transition, and integration (as per the concept of relative importance) is to take maximum advantage of existing programs and utilize their experiential, technical, and human resources. The ideal start-point for NHATS was to take a close look at the Army's Cost and Operational Effectiveness analysis (COEA) program[3,4]. Though far larger than the constraints (Table I) on NHATS would allow, the COEA is a logical basis for the nuclear hardening trade-off methodology.

The current COEA system is a formalized framework of analyses for determining the relative merits of a set of alternatives for a given system which is designed to meet an Army need. The COEA is tasked with estimating the effect of such limited resources as personnel, facilities, and funds on the efficiency of meeting this need. It is also designed to assess the impact of the various alternatives on the battlefield. Specifically, the COEA quantitatively evaluates the alternatives in terms of cost and operational effectiveness.

A COEA is, by necessity, a very structured program. In many instances it involves quite a lengthy process (typically one year), including the commitment of large numbers of personnel from a variety of agencies, and often expending large sums of money. In terms of the NHATS complexity constraints, responsiveness, flexibility, limited resources, and independence/validity (see Table I), the COEA is simply too cumbersome. Therefore, rather than dictate the actual conduct of a COEA, NHATS proposes to borrow heavily from the principles and practices built into the COEA, but on a much smaller scale. NHATS, then, may be thought of as a tailored COEA which is specifically designed to meet both the immediate and ultimate needs (Tables I and II) of the nuclear hardening proponent.

Ten analyses constitute the minimal requisites for a comprehensive COEA[5], and hence have been incorporated into NHATS. The following is a brief synopsis of each:

1. Analysis of Mission Needs, Deficiencies, and Opportunities
The analysis of mission needs is taken in the context of wartime situations (scenarios). The failure of current systems to meet these needs defines system deficiencies. Any area where system efficiency may be increased is the discovery of an opportunity.

2. Analysis of Threats and Other Environments
The analysis of threats and other environments determines the elements that our systems would be used against and the forces that would be used against our systems. Natural, or environmental, hazards are included.

3. Analysis of Constraints
The analysis of constraints determines the factors (i.e., personnel, funding, technical R&D) that limit the number of admissable alternatives.

4. Analysis of the Operational Concepts
The analysis of operational concepts includes operational doctrine and tactics with emphasis on how the system is to be used to accomplish its objectives.

5. Analysis of Specific Functional Objectives
The specific functional objectives are treated as goals the system must meet. The effectiveness of alternative systems is measured in terms of the extent to which these goals would be achieved.

6. Analysis of System Alternatives
The system alternatives are those candidate courses of action or system solutions that offer prospect of meeting the mission objective.

7. Analysis of System Characteristics & Performance
The measure of effectiveness is used to indicate the extent to which a system can meet its objectives. It is determined from knowledge of

system characteristics (weight, size, shape, color, etc.) and system performance (rate-of-fire, cross-country speed, service time, lethal area, etc.).

8. Analysis of Costs
Cost analysis determines the resource implications resultant from a given choice of alternative systems/programs.

9. Analysis of Uncertainties
Uncertainty assessments are a quantitative determination of the extent of sureness regarding the cost modeling and effectiveness modeling as conducted in analyses 1-8 above.

10. Analysis of the Preferred Alternative
Analysis of preferred alternatives includes absolute values of all the measures of cost and all the measures of effectiveness for each alternative. Alternatives based on an explicit criteria of choice may then be ranked.

Mapping each of these ten analyses to a specific function provides the foundation of NHATS design. Table III depicts a skeletal breakdown of these in terms of two major functional categories. As is shown, the trade-off is based on life-cycle cost and operational impact data. The operational impact heading is further divided into the sub-functions of operational context and design. In this manner, NHATS reflects two of the fundamental premises upon which it is based (Table II), repeated here for emphasis.

1. A system's end use and design are not independent.

2. Survivability is a function of cost and operational effectiveness.

Missing from Table III, yet inherent in the process, are the following: the analysis of constraints, which will show itself in the selection of alternatives for consideration prior to initiation of the trade-off; analysis of uncertainties, on-going throughout the conduct of the methodology; and analysis of the preferred alternative, the rank-ordering of results conducted after all other analyses have been concluded.

What remains to be done now is to mold these analyses into a functional flow diagram, while maintaining the structure outlined in Table III. Figure 1 depicts such a flow diagram for NHATS. In particular, the illustration shows the intra- and inter-relationships of the analyses and functions discussed above. It is a reinforcement of the end use/design interaction concept and demonstrates now readily NHATS fits into the doctrinal and materiel acquisition processes of the Army.

Up to this point, NHATS has closely paralleled COEA techniques. A major point of departure, however, occurs in determining the measures of effectiveness (MOE). Though not advocating a radical re-design of

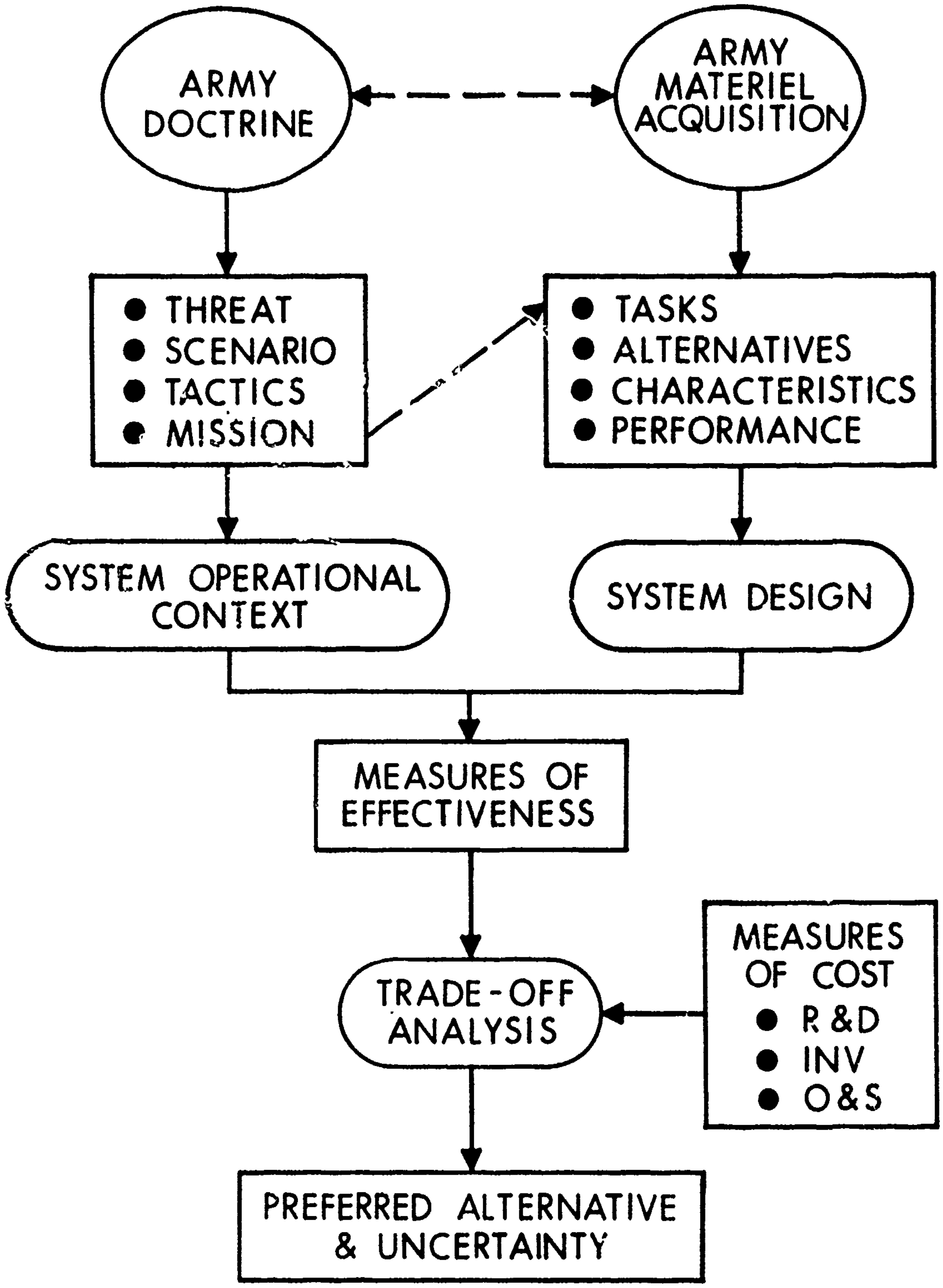

Figure 1. NHATS Functional Flow Diagram

Table III. NHATS Design - COEA Functional Categories

OPERATIONAL EFFECTIVENESS

- SYSTEM OPERATIONAL CONTEXT
  - Analysis of Threats and Other Environments
  - Analysis of Operational Concept
  - Analysis of Mission Needs, Deficiencies, and Opportunities
- SYSTEM DESIGN
  - Analysis of Specific Functional Objectives
  - Analysis of System Characteristics and Performance
  - Analysis of System Alternatives

LIFE-CYCLE COSTS

- RESEARCH AND DEVELOPMENT COSTS
- INVESTMENT COSTS
- OPERATION AND SUPPORT COSTS

conventional methods, NHATS does necessitate the development of a modified approach.

MOE typically vary from system to system based on the nature of the tasks involved. Most often they are defined for a rather high level of aggregation on the battlefield, normally commensurate with the environmental detail of the combat simulations employed (theater level, division level, battalion level, etc.). But the nature of the problem faced by NHATS is slightly more complex than the typical combat environment used in most COEA assessments. Rather than a strictly conventional warfare environment, NHATS is faced with a nuclear/conventional mix. It is reasonable to assume that the nuclear exchange will be preceded by conventional battle and that it may be followed by one. Thus, the combat effectiveness analysis, or attempting to quantify the MOE, takes on a dual nature. The NHATS methodology is designed to handle this situation by means of a "fine-scale" effectiveness analysis in conjunction with a "broad-scale" effectiveness analysis. This two tiered approach is intended to incorporate the outcome of a nuclear excursion (the fine-scale) into the realm of a conventional battle (the broad-scale). Thus, the output of the fine-scale analysis (residual combat capability) becomes input to the broad-scale analysis in terms of a nuclear perturbation to a conventional fight. Figure 2 shows how these two analyses work in concert with one another to develop a comprehensive

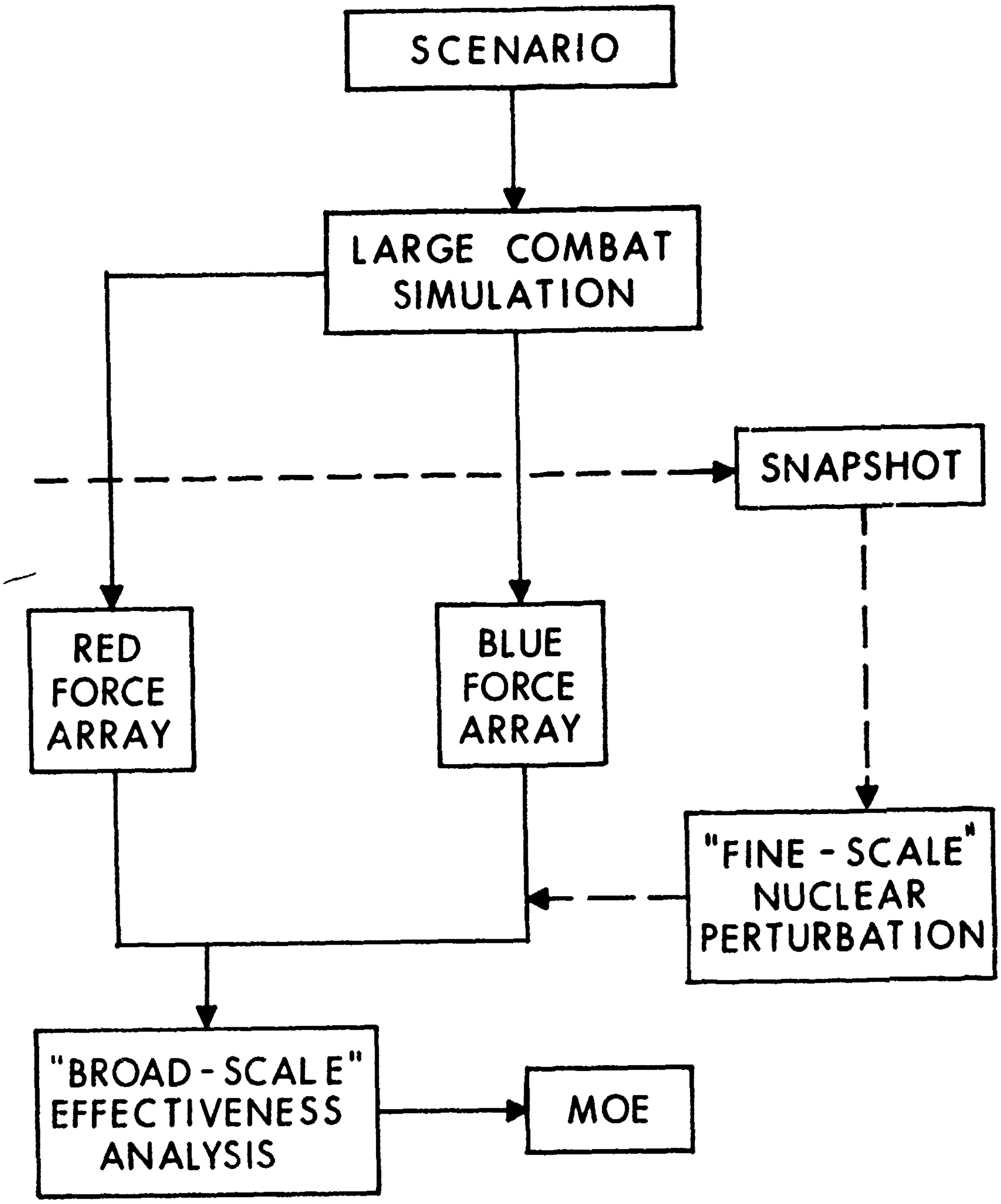

Figure 2. NHATS Effectiveness Analysis

battle simulation. The final output is a MOE which could be applicable to singularly conventional simulations or simulations which are of a nuclear/conventional mix. In other words, the MOE used in standard COEA's are directly applicable to NHATS.

The design of NHATS is now complete and has met the original principles outlined in Section IIA. By adhering closely to the COEA process, NHATS has complied with the relative importance and complexity parameters of Table I. Quantification of the uncertainty of the analyses throughout the methodology is an inherent feature, as mentioned earlier. Thus, the design, or practices, as discussed in this section have formed the basis for initiating the trade-off. All that remains is to develop the procedures for implementation.

C. Implementation

The procedures for implementing NHATS will vary on a case by case basis, primarily as a function of what stage of the materiel acquisition process the system is in. More specifically, the procedures themselves may not necessarily change, but the operational context and system design data obtained by following the procedures will reflect the system's level of development. For example, the situation for nuclear hardening through retrofit (PIP - product improvement proposal) will be one in which the operational context has been well defined and the system base-case design is well known. Life-cycle costs and operational effectiveness studies of the base-case will have been completed. Thus, availability of data and a well-defined baseline is the norm. If, on the other hand, the system under consideration for nuclear hardening is in the conceptual or validation phase of the materiel acquisition cycle, availability of data may be minimal and lead times for generating the requisite information may be greatly increased. But despite this early state of system development, the procedures for obtaining data remain basically unchanged. NHATS will depend on this feature for remaining within its conceptual and design framework, although time lags would most certainly be anticipated.

There are four major organizations involved with NHATS:

1. TRADOC
2. DARCOM
3. ANCA
4. The Project Manager for the System

The first two are involved because the NHATS methodology relies heavily on the COEA process. It is designed to specifically utilize the expertise and procedures of current cost/effectiveness analyses. Thus, the two key commands responsible for the conduct of COEAs, TRADOC and DARCOM, figure prominently in the NHATS program as well.

The Army Nuclear and Chemical Agency (ANCA) plays a vital role in

NHATS in that they are the Army's proponent activity for all nuclear related matters. Since NHATS is a nuclear hardening methodology, ANCA's inclusion cannot be minimized.

The last activity listed is the project manager (PM) for the system under consideration. As the developer of the materiel hardware, it is mandatory that the PM be involved in any hardening efforts. Though much of NHATS is designed to remain independent of PM analyses, a great deal of information and help is available from those analyses. Indeed, NHATS, much like a COEA, cannot be conducted without PM support.

With the major agency liaisons identified, the simplest means of demonstrating the data requirements from the various organizations involved in NHATS (Table III), is to "walk-through" the requisite steps. Figure 3 is the reference for this discussion.

Order is not depicted in this figure as, for most cases, it is extremely situational. Beginning at the top for simplicity, one initiates contact with the project manager (PM) responsible for the system being considered for hardening. Based on a set of alternative courses of action for achieving various levels of hardening, the PM provides the system characteristics and performance which may be affected by each (did the weight change, the color, the dimensions, the rate of fire, etc.?). At DARCOM, the Major Subordinate Command (MSC) responsible for the system's development is contacted. The MSC, and/or other DARCOM laboratories, should supply hardening techniques and options, vulnerability and weapon's effects data, and any other RDTE data pertinent to the analysis. The MSC comptroller office is also requested to provide the life-cycle costs for each hardening alternative (such requests being forwarded through HQ, DARCOM). In many cases this will amount to an incremental cost analysis for a system upon which a COEA has already been conducted. The Army Nuclear and Chemical Agency is then asked to supply the nuclear survivability criteria for the system and the associated hardening envelope, or levels for the various weapon effects. TRADOC is the center for obtaining scenario and threat information with ITAD validating the latter. Also from TRADOC one obtains the Quarterly COEA Forecast (QCF) which lists the COEA points of contact (POC) for all major and designated non-major systems for which COEA's are currently planned or in progress. Listed by name and phone number are the primary personnel involved in the staffing and conduct of the COEA. Next, through the Defense Documentation Center (DDC) and its Catalog of Approved Requirement Documents (CARDS). one may obtain the Required Operational Capability (ROC), Letter of Agreement (LOA), Letter Requirements (LR), and/or Operational Capability Objective (OCO) reports. These list, as a minimum, the mission needs, operational concept, cost limits, effectiveness estimates, schedules, threat environments, and performance characteristics pertaining to the system in question. Finally, if completed, the original COEA may also be obtained from the agency who conducted it or the proponent school for the system.

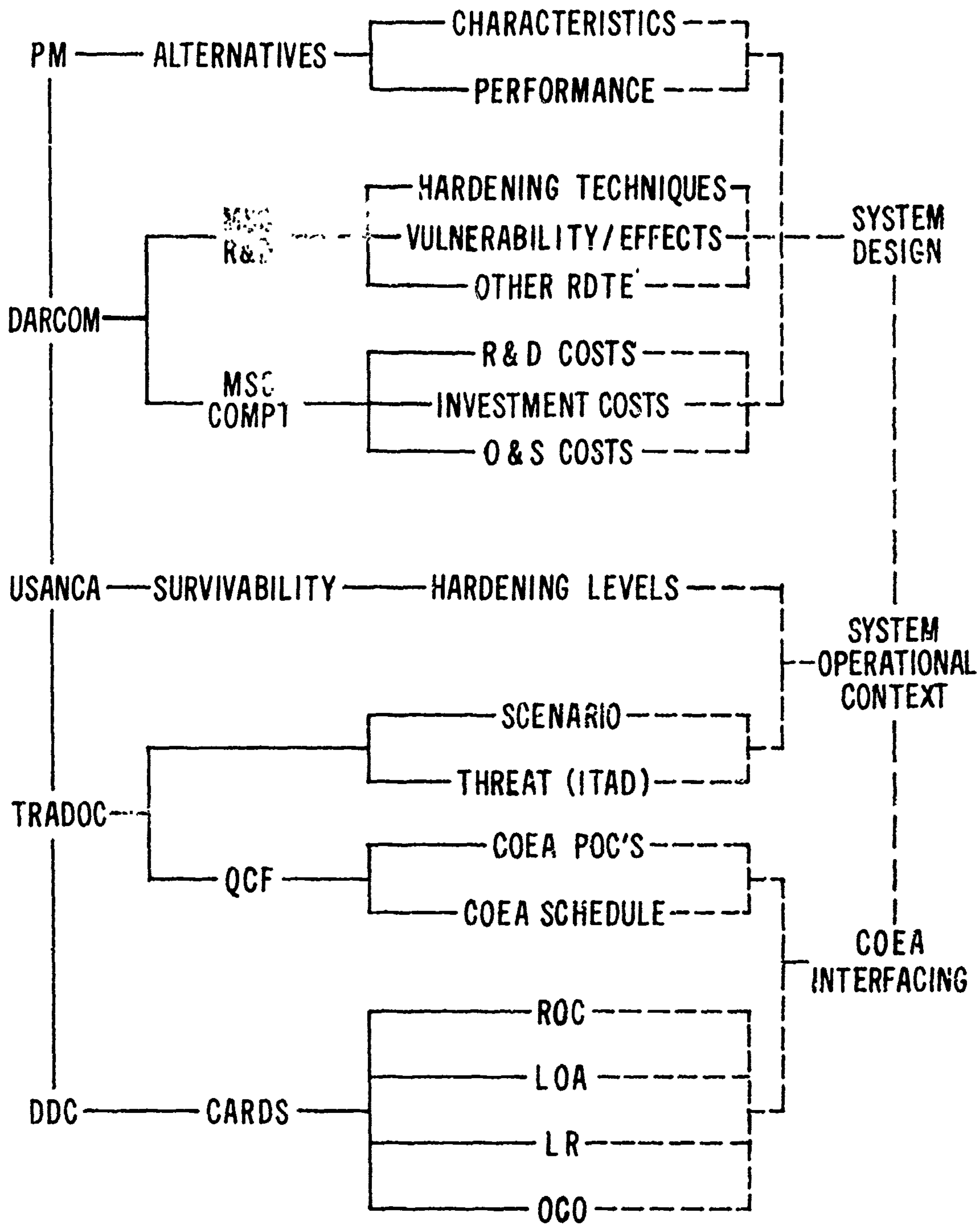

Figure 3. NHATS Implementation

As is shown in Figure 3, all of the above still follow the NHATS design in maintaining the system design and operational context categories. In addition, the bottom section of this figure shows the NHATS/COEA relationship and how the interface is generated.

Once the above has been completed and all the data is in-hand, the effectiveness analysis may be conducted. With the appropriate scenario, threat, and operational context defined, the simulation for the nuclear excursion is completed and its output is used as attrited input to the conventional, broad-scale simulation. The same MOE employed in the COEA are now employed in the NHATS broad-scale analysis. These MOE and the measures of cost (MOC) are then used to develop relative effectiveness and relative cost evaluations for the baseline system and its hardened alternatives. From these, relative worth of the alternatives is derived. The same criterion of choice as selected for the COEA may then be applied to NHATS, and a ranking of preferred alternatives via an appropriate optimization scheme completes the process.

In short, this outlines NHATS implementation. As has been shown, the parallelism between NHATS and COEA's is taken as a major advantage and is used to its fullest.

III. SUMMARY

A. Conclusions

The NHATS design meets the immediate needs and ultimate goals for which i was intended. The relative importance of NHATS has been identified ir terms of visibility, commitment, transition, and integration and these have been incorporated via maximum utilization of current Army programs, agencies, personnel, and technical resources. The complexity of NHATS has been addressed with regard toward responsiveness, flexibility, limited resources, and independence/validity. The responsiveness has been designed to produce end results in a matte of months, if not weeks, by relying heavily on work already completed and available. Flexibility is assured by taking advantage of the fact that every system in the Army is developed through the same materiel acquisition process. Thus, the requisite requirements documents for NHATS are generated for all Army materiel. Redundancy is accounted for in many cases by the fact that COEA's, ROC's, LR's, and LOA's will often contain similar information. One of these may be suitable when others are not yet available. Constraints on resources (human and technical) have been considered by NHATS in that the computer simulations of the fine and broad scale effectiveness analyses are "in-house" Army programs, codes, and computer systems. Independence/validity has been achieved by conducting the effectiveness analyses in Army laboratories or agencies not associated with PM's and by using cost data verified by the Comptroller of the Army. Uncertainty has been tasked to the individual agencies providing data for NHATS. NHATS assures obtaining and maintaining this data. The ultimate goals of NHATS have been met by presenting a viable, comprehensive program for analyzing and optimizing the relative worth of hardening alternatives based on quantitative operational impact and life-cycle cost assessments. It does this based on the facts that end use and design are interdependent, that survivability is a function of cost and operational effectiveness, and that the tactical nuclear battlefield is in actuality a nuclear/conventional mix. Based on these, a program has been developed which is NOT a COEA, but which is designed to be heavily dependent upon COEA's and is carefully structured to interface efficiently with them so that the nuclear hardening of Army materiel may proceed in the same cost/benefit manner as conventional systems. The COEA is a proven, accepted, operating method. NHATS was designed to recognize this and take advantage of it accordingly.

B. Recommendations

The NHATS trade-off methodology presented in this report has been an initial effort to develop a program upon which nuclear hardening alternatives may be judged in terms of their cost and operational impact. As designed, the NHATS methodology closely parallels the Army's COEA program. Demonstration of the applicability of NHATS and its ability to interface with a COEA is currently underway. The TACFIRE system has been selected as the trial candidate or test case.

Full appreciation of the merits of NHATS, and more importantly a greater knowledge of its weaknesses, will not be realized with the limited effort being expended on the TACFIRE example. That nuclear hardening can be assessed in terms of cost and operational impact, however, is demonstrable. It is with this contention, then, that a full-scale trial run of the program should be conducted. This would include the multiple agency interaction and go beyond much of the "walk-through" anticipated with the TACFIRE example. An effort of this scope should include the newly created Nuclear Systems Office at HQ, TRADOC, the Army Nuclear and Chemical Agency at Ft. Belvoir, and the Nuclear Weapons Effects Program Office (and agencies that they sponsor) of DARCOM. Jointly, these groups would be ideally suited to conduct the NHATS trade-off on a scale above the conceptual level and help effect the "fine-tuning" which is so necessary for a program of this nature. In essence this would constitute a validation phase for NHATS which would verify and indeed improve the methodology as a systematic approach to an Army-wide, life-cycle muclear hardening program.

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